MAKAKILO CITY, PALAILAI NEIGHBORHOOD
RESERVOIR NO. 3 - SOIL EXPLORATION REPORT

HONOULIULI, EWA, OAHU, HAWAII
TAX MAP KEY: 9-2-03

To:
SUNN, LOW, TOM & HARA, INCORPORATED

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

OCTOBER 9, 1970

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

WALTER LUM
EDWARD WATANABE
EZRA KOIKE

3030 WAIALAE AVE., HONOLULU, HAWAII 96816 • TEL. 737-7931

October 9, 1970

SUNN, LOW, TOM & HARA, INC.
1000 Bishop Street
Honolulu, Hawaii 96813

Gentlemen:

Subject: Makakilo City, Palailai Neighborhood
Reservoir No. 3 - Soil Exploration Report
(for foundation design purposes)
Honouliiuli, Ewa, Oahu, Hawaii
Tax Map Key: 9-2-03

Transmitted herewith is our soil exploration report for the Makakilo City Reservoir No. 3 at Palailai Neighborhood, Honouliiuli, Ewa, Oahu, Hawaii.

Boring Nos. 1 and 2 indicated decomposed rock to about 2-ft depth underlain with lava rock to about 35 ft. Boring No. 3 generally indicated mottled-brown clayey silt with decomposed rock to about 30 ft underlain with lava rock to about 40 ft.

For the proposed reservoir structure, continuous footing or slab foundations may be considered.

This report includes a Boring Location Plan, boring logs, laboratory test results, recommendations and limitations.

Respectfully submitted,

WALTER LUM ASSOCIATES, INC.

Ezra Koike

Ezra Koike
Professional Engineer
Hawaii No. 1450

EK:rmf

C O N T E N T S

MAKAKILO CITY, PALAILAI NEIGHBORHOOD
RESERVOIR NO. 3 - SOIL EXPLORATION REPORT

HONOULIULI, EWA, OAHU, HAWAII
TAX MAP KEY: 9-2-03

SCOPE OF EXPLORATION

The purpose of this exploration was to determine general soil conditions at the proposed site of the 1.5 M.G. Makakilo City Reservoir No. 3 for foundation design.

This report includes preliminary field exploration, laboratory tests and recommendations for the tank foundation design.

FIELD EXPLORATION

Three exploratory borings were made at the site as shown on the Boring Location Plan. Borings were made with 4-in. diameter augers using carbide bits and "BXM" core barrel using diamond coring bits.

Soil samples were recovered with a 2-in. standard split spoon sampler driven with a 140-lb hammer falling 30 inches. Rock samples were recovered with a "BXM" core barrel.

LABORATORY TESTS

Laboratory tests included: natural water content, Atterberg limits, natural density, expansion and CBR. A summary of the laboratory test results is given in Tables IA and IB.

Soil samples were visually observed and subjected to appropriate tests in the laboratory. Based on visual observations and laboratory tests, the soil descriptions given on the boring logs are generally made in accordance with the "Unified Soil Classification System."

GENERAL SITE CONDITIONS

The project site is located about 1.5 miles northwest of the intersection of Makakilo Drive and H-1 Freeway. The proposed site is located near the top of a ridge that slopes downward at about 10 to 25% gradient towards the southeast.

A dirt access road crosses the central portion of the site.

The existing ground surface appears to be weathered and eroded volcanic rock sparsely covered with brush. Several lava rock exposures were noted generally between Boring Nos. 1 and 2.

INTERPRETATION OF SOIL CONDITIONS

From the field exploration, the soils at the site may be described as follows:

Boring Nos. 1 and 2 indicated decomposed rock to about 2-ft depth underlain with lava rock to about 35 ft, the depth drilled in Boring No. 1. Boring No. 3 generally indicated stiff mottled-brown clayey silt with decomposed rock to about 30-ft depth underlain with lava rock to about 40 ft, the depth drilled.

Ground water or seepage was not noted in the borings during the exploration.

For more detailed descriptions of soils encountered in the drill holes, refer to the boring logs.

DISCUSSION AND RECOMMENDATIONS

A 120-ft diameter 1.5 M.G. tank is proposed at the site. The proposed site grading indicates cuts up to about 22 ft in height and shallow fills for a perimeter road east of the site.

Foundations

The plans indicate a bottom of tank elevation of about 900 ft. On the high side of the site, the grading would involve cut up to about 22 ft, and on the low side, minor grading is proposed.

For tank foundations, a level platform is usually made by excavating down to about the approximate subgrade below the finish floor of the tank.

The excavation should preferably be made to such depths to generally comply with the following conditions:

1. The excavation should extend 10 ft beyond the outside perimeter of the tank.

2. The depth of excavation to the finish floor at any point around the perimeter of the tank should be about 1/2 the height of the tank.

By making the tank excavation approximately equal to 1/2 the height of the tank, the weight of a full water tank will be approximately equal to the weight of the materials removed. This will minimize differential settlements because little, if any, additional stresses are added to the underlying soft spots and clinker pockets or lava tubes that may go undetected.

Because of the varying underlying materials from soil to hard rock at the proposed location, if the tank foundations are set at the proposed location, differential settlements of one or more inches may occur.

After the excavation is made for the perimeter and column footings, the ground should be probed for several feet below the excavation to check for soft spots or void spaces.

The final tank location may be shifted several feet out in the field after the excavation and soil conditions are better exposed.

If soft spots or voids are encountered below the excavation, they should be removed and backfilled with compacted crusher run rock (3/4" to 0") or with low grade concrete.

The bottoms of all footing excavations should be well compacted before placing any concrete.

Continuous footing or slab foundations may be used. The footings around the perimeter of the tank should extend to at least 3 ft below the finish grade, or designed with a cut-off wall that extends below the invert of the perimeter subdrain that is placed around the tank. Bearing values of 2000 p.s.f. may be used.

Site Grading

Provisions should be made to drain the excavation at all times. Footings for the tank should be constructed immediately after the grading and preparation of the foundation subgrade.

Grading should be done in general conformance with the requirements of Chapter 23, Revised Ordinances of Honolulu, 1961 As Amended.

Guide lines regarding site grading are as follows:

1. Surface vegetation and miscellaneous debris should be cleared and removed prior to site filling.

2. Localized soft pockets encountered during site preparations should be excavated and backfilled with compacted select material or low grade concrete.

3. In general, the on-site soils may be used for the construction of the proposed fills. If fill material is imported to the site, it should be select non-expansive material generally less than 3-in. maximum size and with a plasticity index of less than 15.

4. Fills should be constructed in approximately level layers starting at the lower end and working upward. Fills should be laid in 6-in. compacted layers with a relative density of at least 90% of AASHO T-180-57 density.

Slopes

Cut slopes of 1-1/2 to 1 may be used in the soil and about 3/4 to 1 in volcanic rock that is fairly homogeneous. An overall average slope of 2 to 1 or flatter slopes is preferable for the soils.

Fill slopes should be 2 to 1.

Slope adjustments or other precautions may be necessary if seepage zones or soft spots are encountered in localized areas. Slope planting is recommended to minimize erosion.

The height of slopes should be limited to about 30 to 40 ft with 8-ft wide benches at about 15 to 20-ft height intervals. For cuts in rock, the bench may not be necessary for the cut slopes proposed.

Erosion may be a problem in the soils. Runoff should be diverted from the slopes.

Roadway Pavement

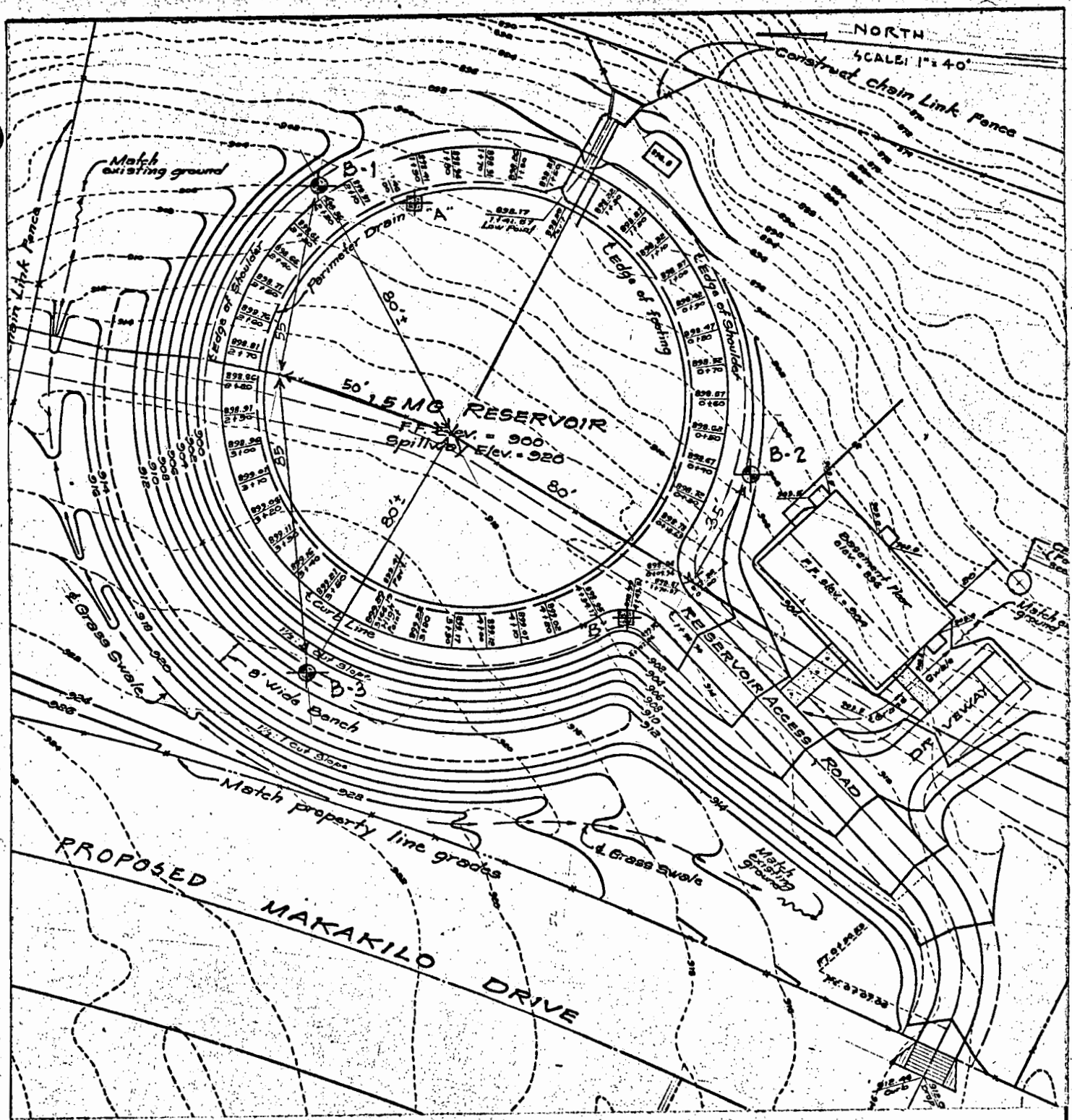
A rough estimate of the roadway pavement thickness for the light traffic anticipated is as follows:

1. Wearing course - 2-in. asphaltic concrete.
2. Base course - 6-in. base course over a prepared subgrade.

The subgrade should be compacted and shaped to drain. To avoid the ponding of water and softening of the subgrade at low points, weep holes should be placed at subgrade level thru the walls of catch basins.

Unforeseen Conditions

Unforeseen or undetected conditions such as soft spots or seepage water may occur in localized areas and will have to be adjusted and corrected in the field as they are detected.



LEGEND:

- BORING
- SURFACE SAMPLE

BORING LOCATION PLAN

MAKAKILO CITY, PALAILAI NEIGHBORHOOD

RESERVOIR NO. 3

HONOULIULI, EWA, OAHU, HAWAII

TAX MAP KEY: 9-2-03

WALTER LUM ASSOCIATES, INC.

CIVIL, STRUCTURAL, SOILS ENGINEERS

BORING LOGS

Symbols

Symbols used generally are in accordance with the Unified Soil Classification System.

Where a parenthesis "(MH)" is used, the soil sample was classified by visual observation of the sample recovered.

Where no parenthesis "MH" is used, the soil sample was classified from either the Atterberg limits or sieve analysis test results.

MAKAKILO RES. NO. 3

WALTER LUM ASSOCIATES

3030 WAIALAE AVENUE • HONOLULU, HAWAII 96816 • PHONE 737-7931

Boring Log

PROJECT: MAKAKILO CITY RESERVOIR NO. 3

LOCATION: Honouliuli, Ewa, Oahu, Hawaii

Tax Map Key: 9-2-03

HAMMER: Weight 140 # Drop 30"

SAMPLER: 2"ss - 2" STANDARD SPLIT SPOON; BXM - BXM DOUBLE CORE BARREL

BORING NO. 1 Sheet No. ____ of ____

Driller WALTER LUM ASSOC Date SEPT. 4, 1970

Field Party SUZUKI, KAKU

Type of Boring AUGER (ACKER ACE) Diam. 4"

Elev. 906'± * Datum —

Drill Bit T.C. DRAG & DIAMOND CORING

Water Level	NOT NOTICED				
Time	—				
Date	9-14-70				

Unified Soil Classification	DESCRIPTION	Depth (Ft.)	Sampler	Sample No.	Plastic Limit	Water Cont. %	Liquid Limit	Unconf. Comp. P.S.F.	Vane Shear P.S.F.	PENETRATION DATA: Standard Penetration Test, N (Blows per foot) 0 10 20 30 40
	ELEV. = 906'±2 *	0								
CL-ML	REDDISH BROWN, SILTY CLAY (DECOMPOSED ROCK)		2"ss	1-A	-	4	-	-	-	40/1'
		5	BXM	RUN # 1		CORED 5.5' RECOV. 4.3'				
	LAVA ROCK	10	BXM	RUN # 2		CORED 5.0' RECOV. 5.0'				
	NOTE: LOST WATER AT 13.0'-13.5' DEPTH. PACKED VOID AREA W/BENTONITE-CEMENT MIXTURE AND CONTNUED DRILLING W/ MUD CIRCULATION.		BXM	RUN # 3		CORED 1.5' RECOV. 1.0'				
		15	BXM	RUN # 4		CORED 4.0' RECOV. 4.0'				
	LAVA ROCK	20	BXM	RUN # 5		CORED 5.0' RECOV. 4.8'				
		25	BXM	RUN # 6		CORED 4.5' RECOV. 4.5'				
			BXM	RUN # 7		CORED 2.5' RECOV. 1.2'				
		30	2"ss	1-B		25				25/5" 83/5'
	DECOMPOSED ROCK									
	LAVA ROCK		BXM			CORED 2.5' RECOV. 1.7'				
	BROWN, CLAYEY SILT & ROCK FRAGMENTS (DECOMPOSED ROCK)	35	2"ss	1-C	-	17	-	-	-	56/.5'
	END OF BORING @ 34.5'									
	* ELEVATION ESTIMATED FROM GRADING PLAN									

MAKAKILO RES. NO. 3

WALTER LUM ASSOCIATES

3030 WAIALAE AVENUE • HONOLULU, HAWAII 96816 • PHONE 737-7931

Boring Log

PROJECT: MAKAKILO CITY RESERVOIR NO. 3

LOCATION: Honouliuli, Ewa, Oahu, Hawaii
Tax Map Key: 9-2-03

HAMMER:
Weight: 140#
Drop: 30"

SAMPLER: 2"ss - 2" STANDARD SPLIT SPOON
BX - BX DOUBLE CORE BARREL

BORING NO. 2 Sheet No. ____ of ____
Driller: WALTER LUM ASSOC. Date: SEPT. 15, 1970
Field Party: SUZUKI, HASHIDA
Type of Boring: AUGER (ACKER ACE) Diam.: 4"
Elev.: 907'± * Datum: —
Drill Bit: DIAMOND BIT

Water Level				
	NOT NOTICED			
Time	—			
Date	9-15-70			

Unified Soil Classification	DESCRIPTION	Depth (Ft.)	Sampler	Sample No.	Plastic Limit	Water Cont. %	Liquid Limit	Unconf. Comp. P.S.F.	Vane Shear P.S.F.	PENETRATION DATA: Standard Penetration Test, N (Blows per foot) 0 10 20 30 40
	ELEV. = 907'± 7*	0								
CL-ML	REDDISH BROWN, CLAYEY SILT { DECOMPOSED ROCK		2"SS	2-A	26	11	41	—	—	41
	LAVA ROCK	5	BX	RUN #1		CORED		4'		
						RECOV.		3.6'		
			BX	RUN #2		CORED		4'		
	DECOMPOSED ROCK	10				RECOV.		3.8'		
			BX	RUN #3		CORED		7'		
	LAVA ROCK	15				RECOV.		7'		
			BX	RUN #4		CORED		3.5'		
	END OF BORING @ 20.5'	20				RECOV.		3.5'		

* ELEVATION ESTIMATED FROM GRADING PLAN

MAKAKILO RESERVOIR No. 3

WALTER LUM ASSOCIATES

3030 WAIALAE AVENUE • HONOLULU, HAWAII 96816 • PHONE 737-7931

Boring Log

PROJECT: MAKAKILO CITY RESERVOIR NO. 3

LOCATION: Honouliuli, Ewa, Oahu, Hawaii

Tax Map Key: 9-2-03

HAMMER:
Weight: 140#
Drop: 30"

SAMPLER: 2" STANDARD SPLIT SPOON

BORING NO. 3 Sheet No. ____ of ____

Driller: WALTER LUM ASSOC. Date: AUG. 31

Field Party: SUZUKI, KAKU, MAESHIRO

Type of Boring: AUGER (ACKER ACE) Diam.: 4"

Elev.: 920'± * Datum: —

Drill Bit: T.C. DRAG

Water Level					
	NOT NOTICED				
Time	—				
Date	9-2-70				

Unified Soil Classification	DESCRIPTION	Depth (Ft.)	Sampler	Sample No.	Plastic Limit	Water Cont. %	Liquid Limit	Unconf. Comp. P.S.F.	Vane Shear P.S.F.	PENETRATION DATA: Standard Penetration Test, N (Blows per foot) 0 10 20 30 40
	ELEV. = 920'±? *	0								
(ML)	LOOSE (DRY) TO STIFF, REDDISH BROWN, CLAYEY SILT W/ROOTS			3-A	-	17	-	-	-	2/.5' 13/.5'
(MH)	STIFF, MOTTLED BROWN, SILTY CLAY W/ DECOMPOSED ROCK	5		3-B	-	23	-	-	-	46
MH	STIFF, MOTTLED GRAY, CLAYEY SILT W/TRACES OF DECOMPOSED ROCK	10		3-C	34	33	53	-	-	45
ML		15		3-D	29	38	44	-	-	20/.5' 40/.5'
		20		3-E	-	21	-	-	-	90/.5'
	DECOMPOSED ROCK	25		3-F	NO RECOVERY					30/.1'
		30		3-G	ROCK FRAGMENT					50/.1'
	LAVA ROCK	35		3-H	NO RECOVERY					40/.0' HAMMER BOUNCES
	END OF BORING @ 40.1'	40		3-I	NO RECOVERY					50/.1' HAMMER BOUNCES

* ELEVATION ESTIMATED FROM GRADING PLAN

MAKAKILO CITY PALAILAI NEIGHBORHOOD
RESERVOIR NO. 3

TABLE I A - SUMMARY OF LABORATORY TEST RESULTS

BORING NO.	1		2	2
SAMPLE NO.				A
DEPTH BELOW SURFACE	SURFACE		SURFACE	0.0 TO 1.5'
DESCRIPTION	REDDISH BROWN SILTY CLAY (DEC. ROCK)		REDISH BROWN SILTY CLAY	REDDISH BROWN CLAYEY SILT & DEC. ROCK
GRAIN-SIZE ANALYSIS (% Passing) Sieve				
1"	100		100	
1/2"	97.0		100	
#4	92.4		98.2	
#10	91.5		97.9	
#20	91.1		97.6	
#40	90.9		97.3	
#100	89.8		96.7	
#200	87.6		95.9	
ATTERBERG LIMITS				
Air Dried or Natural	NATURAL		NATURAL	NATURAL
Liquid Limit	47		44	41
Plastic Limit	27		26	26
Plasticity Index	20		18	15
Dilatancy	QUICK		QUICK	QUICK
Toughness	SLIGHT-MED.		SLIGHT-MED	SLIGHT
Dry Strength	SLIGHT-MED.		MEDIUM	SLIGHT-MED.
UNIFIED SOIL CLASSIFICATION	ML-CL		ML-CL	ML
APPARENT SPECIFIC GRAVITY				
EXPANSION AND CBR TESTS (Surcharge-51 P.S.F.)				
Molding Moisture, %	25.0		26.8	
Molding Dry Density, P.C.F.	97.1		99.1	
Swell upon saturation, %	NIL		0.2	
CBR at 0.1" Penetration	21.5		6.8	
MOISTURE-DENSITY RELATIONS OF SOILS (AASHO T-180-57 Method)			A	
Dry to Wet or Wet to Dry			DRY TO WET	
Max. Dry Density (P.C.F.)			104.0	
Optimum Moisture (%)			24.4	

REMARKS:

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

Date 10-12-70 By BT

MAKAKILO CITY, PALAILAI NEIGHBORHOOD
RESERVOIR NO. 3

TABLE I B - SUMMARY OF LABORATORY TEST RESULTS

BORING NO.	3	3		
SAMPLE NO.	C	D		
DEPTH BELOW SURFACE	10'-11.5'	15'-16.5'		
DESCRIPTION	MOTTLED GRAY CLAYEY SILT W/ TRACES OF DEC. ROCK.	MOTTLED GRAY CLAYEY SILT W/ TRACES DEC. ROCK		
GRAIN-SIZE ANALYSIS (% Passing)				
Sieve				
1"				
1/2"				
#4				
#10				
#20				
#40				
#100				
#200				
ATTERBERG LIMITS				
Air Dried or Natural	NATURAL	NATURAL		
Liquid Limit	53	44		
Plastic Limit	34	29		
Plasticity Index	19	15		
Dilatancy	QUICK	QUICK		
Toughness	SLIGHT	SLIGHT		
Dry Strength	SLIGHT-MED	SLIGHT-MED		
UNIFIED SOIL CLASSIFICATION	MH	ML		
APPARENT SPECIFIC GRAVITY				
EXPANSION AND CBR TESTS (Surcharge-51 P.S.F.)				
Molding Moisture, %				
Molding Dry Density, P.C.F.				
Swell upon saturation, %				
CBR at 0.1" Penetration				
MOISTURE-DENSITY RELATIONS OF SOILS (AASHO T-180-57 Method ___)				
Dry to Wet or Wet to Dry				
Max. Dry Density (P.C.F.)				
Optimum Moisture (%)				

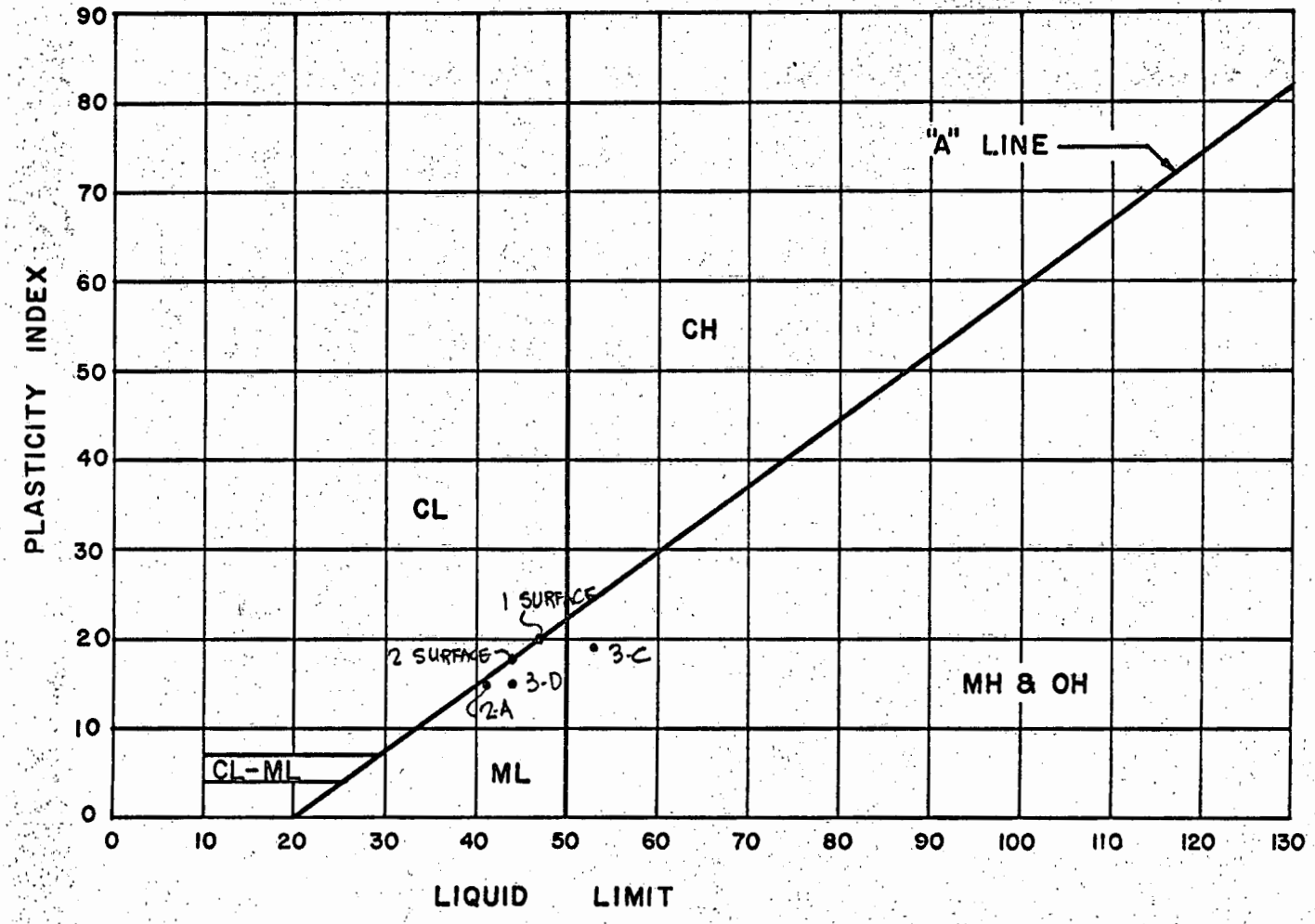
REMARKS:

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

Date 10-12-70 By BT

PLASTICITY CHART

PROJECT: MAKAKILO CITY, PALAILAI NEIGHBORHOOD
RESERVOIR NO. 3
LOCATION: HONOULIULI, OAHU, HAWAII



DATE 9-25-70 BY BT.

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

MOISTURE-DENSITY CURVE (AASHO T-180-57, METHOD A)

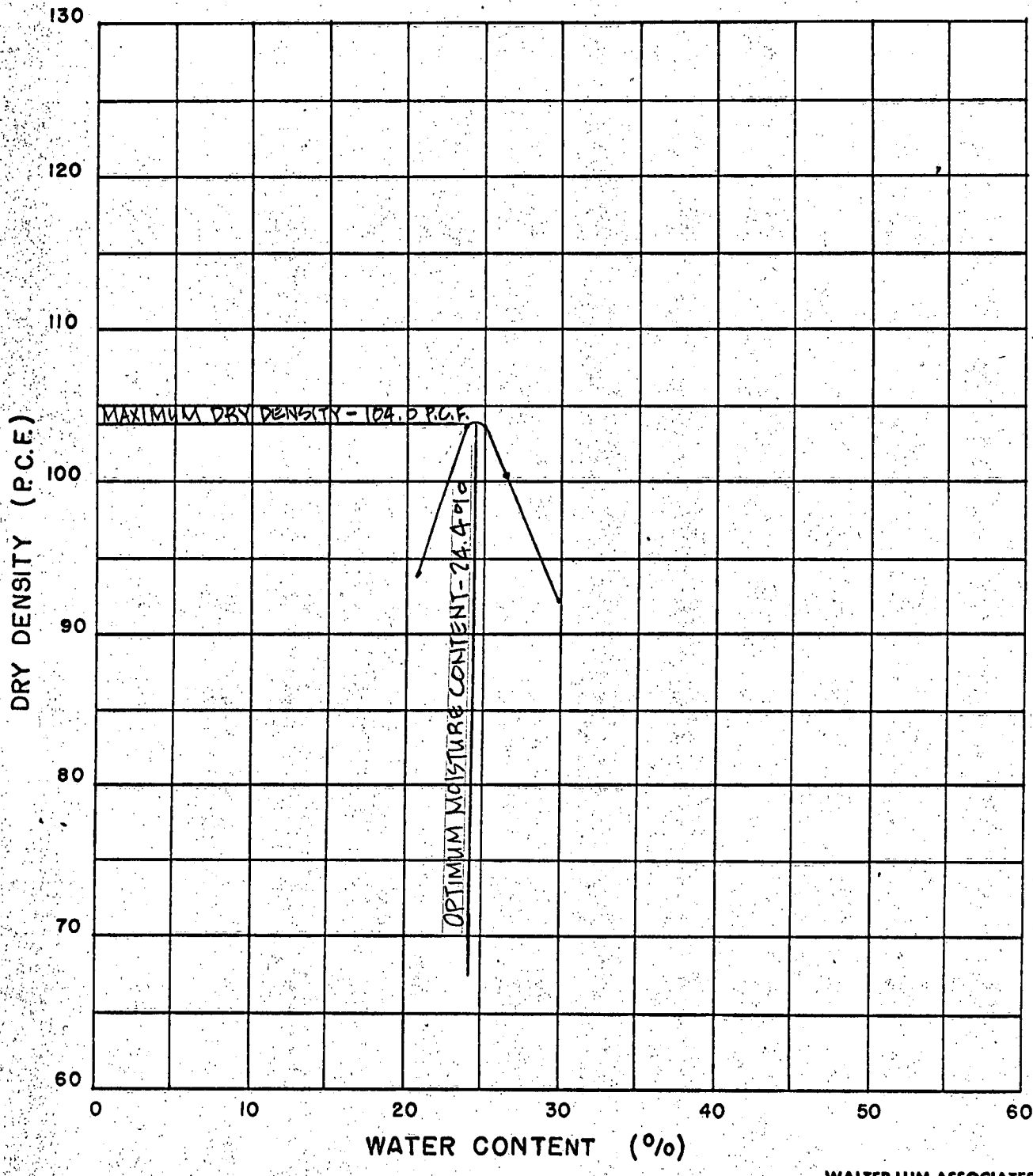
PROJECT: MAKAKILO CITY, PALAILAI NEIGHBORHOOD RESERVOIR NO. 3

LOCATION: HONOULIULI, EWA, OAHU, HAWAII

SAMPLE NO.: 2 SURFACE

SAMPLE DESCRIPTION: REDDISH-BROWN SILTY CLAY

AGGREGATE: 1/4" MINUS
MOLD SIZE: 4" & 4.59"
HAMMER: 10 LBS. 18" DROP
LAYERS: 5
BLOWS: 25 PER LAYER



WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

DATE 9.28.70 BY G.T.

9-470

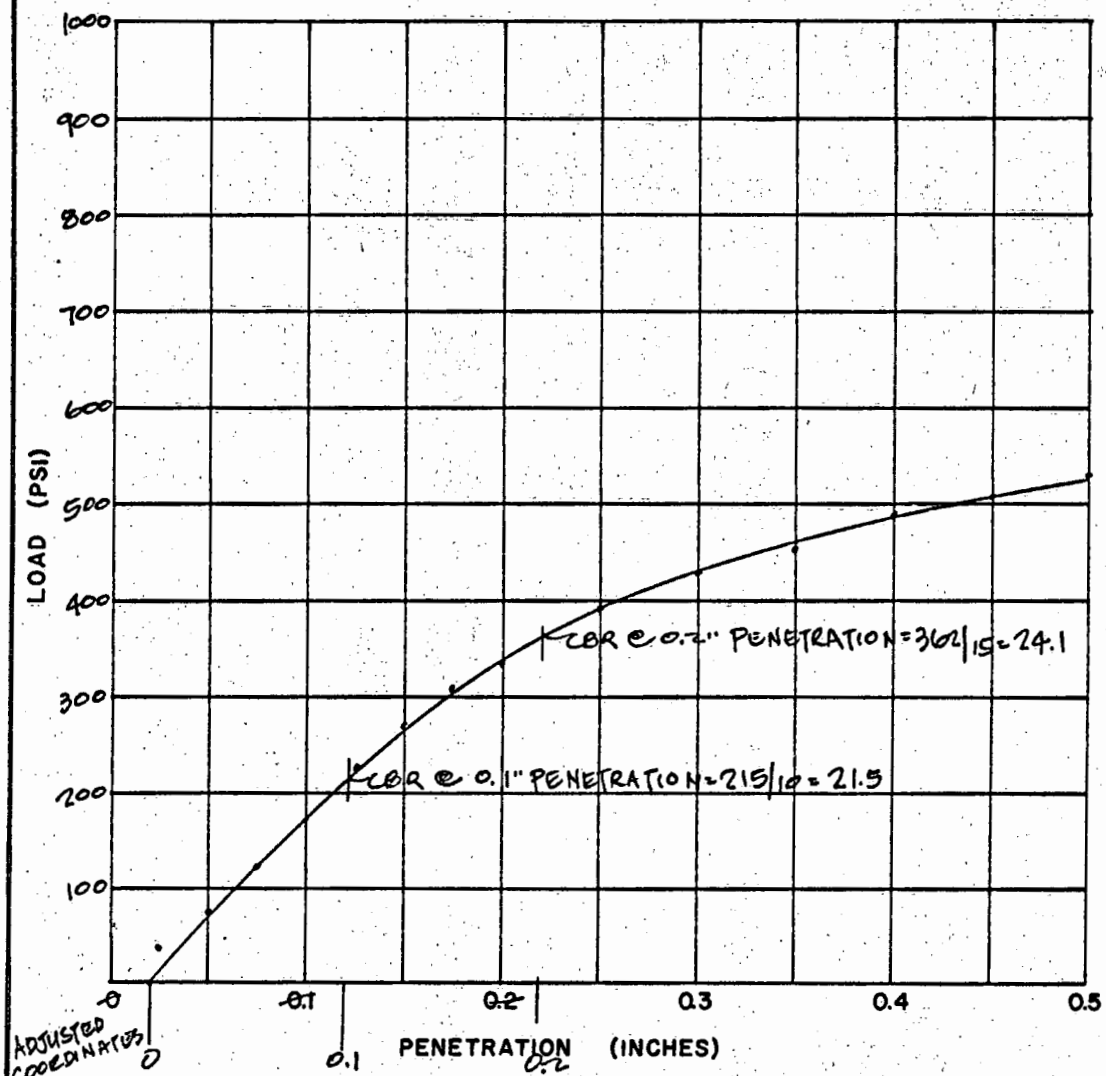
CBR TEST

PROJECT: MAKAKILO CITY, PALAILAI NEIGHBORHOOD RESERVOIR NO. 3

LOCATION: HONOULIULI, EWA, OAHU, HAWAII

SAMPLE NO: 1 SURFACE

SAMPLE DESCRIPTION: REDDISH-BROWN SILTY CLAY (ML-CL)



CBR PENETRATION DATA

PENETRATION (INCHES)	LOAD (LBS.)	LOAD (PSI)
0.025	110	37
0.050	230	77
0.075	370	123
0.100	520	173
0.125	680	227
0.150	810	270
0.175	920	307
0.200	1010	337
0.250	1180	393
0.300	1290	430
0.350	1370	457
0.400	1470	490
0.450	1520	507
0.500	1600	533

AGGREGATE ¼" MINUS

HAMMER WEIGHT 10 LBS

HAMMER DROP 18"

No. OF BLOWS 56

No. OF LAYERS 5

TEST RESULTS:

MOLDING MOISTURE, %. 25.0

MOLDING DRY DENSITY, P.C.F. 97.1

CBR @ 0.1" PENETRATION 21.5

DATE 9.30.70 BY AF

DATE 10.6.70 BY GS

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

10-470

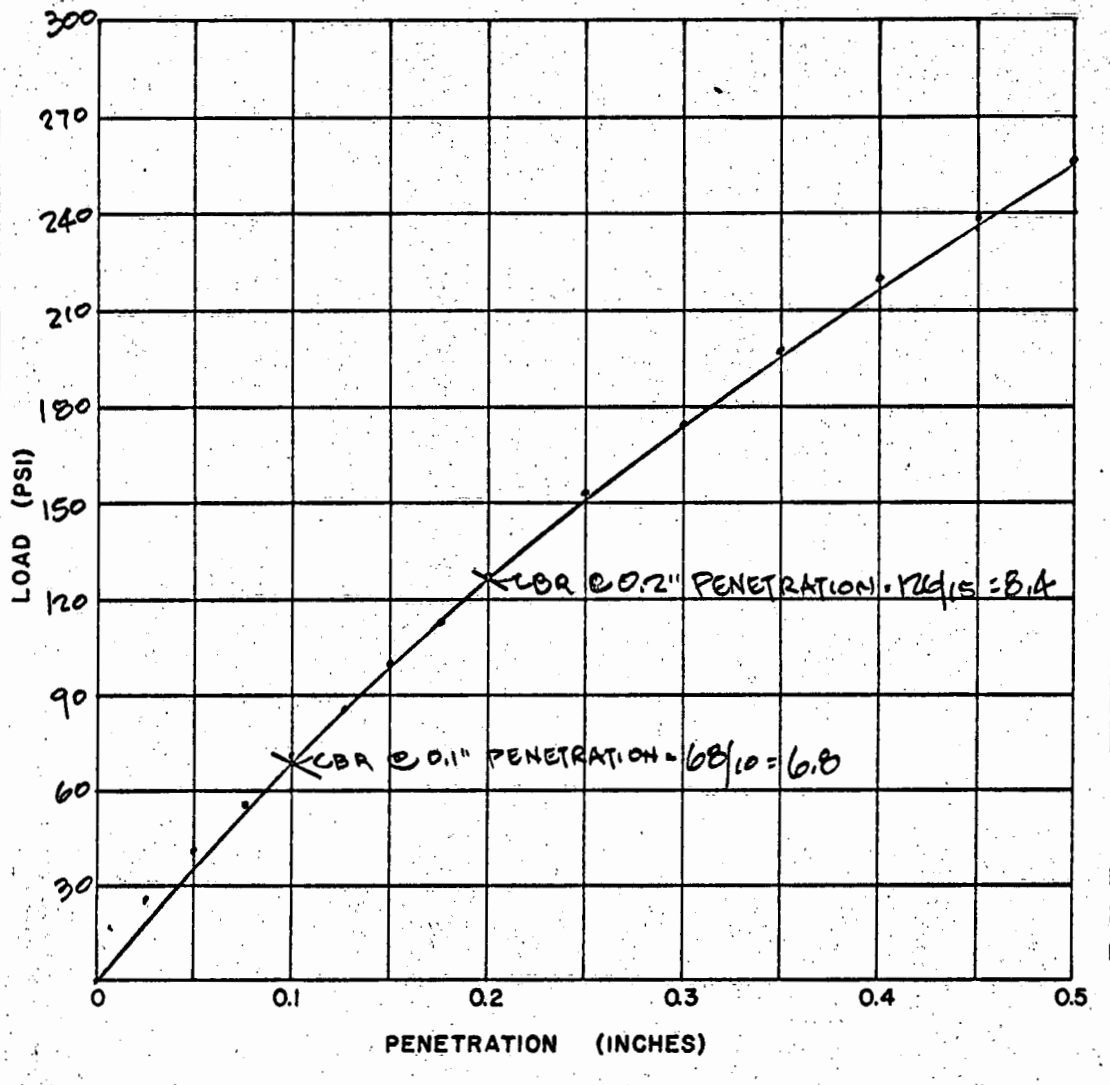
CBR TEST

PROJECT: MAKAKILO CITY, PALAILAI NEIGHBORHOOD, RESERVOIR NO. 3

LOCATION: HONOULIULI, EWA, OAHU, HAWAII

SAMPLE NO: 2 SURFACE

SAMPLE DESCRIPTION: REDDISH-BROWN SILTY CLAY (ML-CL)



CBR PENETRATION DATA

PENETRATION (INCHES)	LOAD (LBS.)	LOAD (PSI)
0.025	75	25
0.050	120	40
0.075	165	55
0.100	210	70
0.125	255	85
0.150	300	100
0.175	345	115
0.200	385	128
0.250	460	153
0.300	525	175
0.350	595	198
0.400	660	220
0.450	715	238
0.500	770	257

AGGREGATE _____

HAMMER WEIGHT 10 LBS.

HAMMER DROP 18"

No. OF BLOWS 56

No. OF LAYERS 5

TEST RESULTS:

MOLDING MOISTURE, %. 26.8

MOLDING DRY DENSITY, P.C.F. 99.1

CBR @ 0.1" PENETRATION 6.8

DATE 9-26-70 BY L.M.

DATE 10-1-70 BY S.T.

WALTER LUM ASSOCIATES, INC.
CIVIL, STRUCTURAL, SOILS ENGINEERS

LIMITATIONS

In general, soil formations are commonly erratic and rarely uniform or regular. The boring logs indicate the approximate subsurface soil conditions encountered only at the drill holes where the borings were made at the times designated on the logs and may not represent conditions at other locations or at other dates. Soil conditions and water levels may change with the passage of time and construction methods or improvements at the site.

During construction, should subsurface conditions much different from those in the borings be observed, encountered, or otherwise indicated, we should be advised immediately to review or reconsider our recommendations in light of the new developments.

Our professional services were performed, findings obtained and recommendations prepared in accordance with generally accepted engineering practices. This warranty is in lieu of all other warranties expressed or implied.